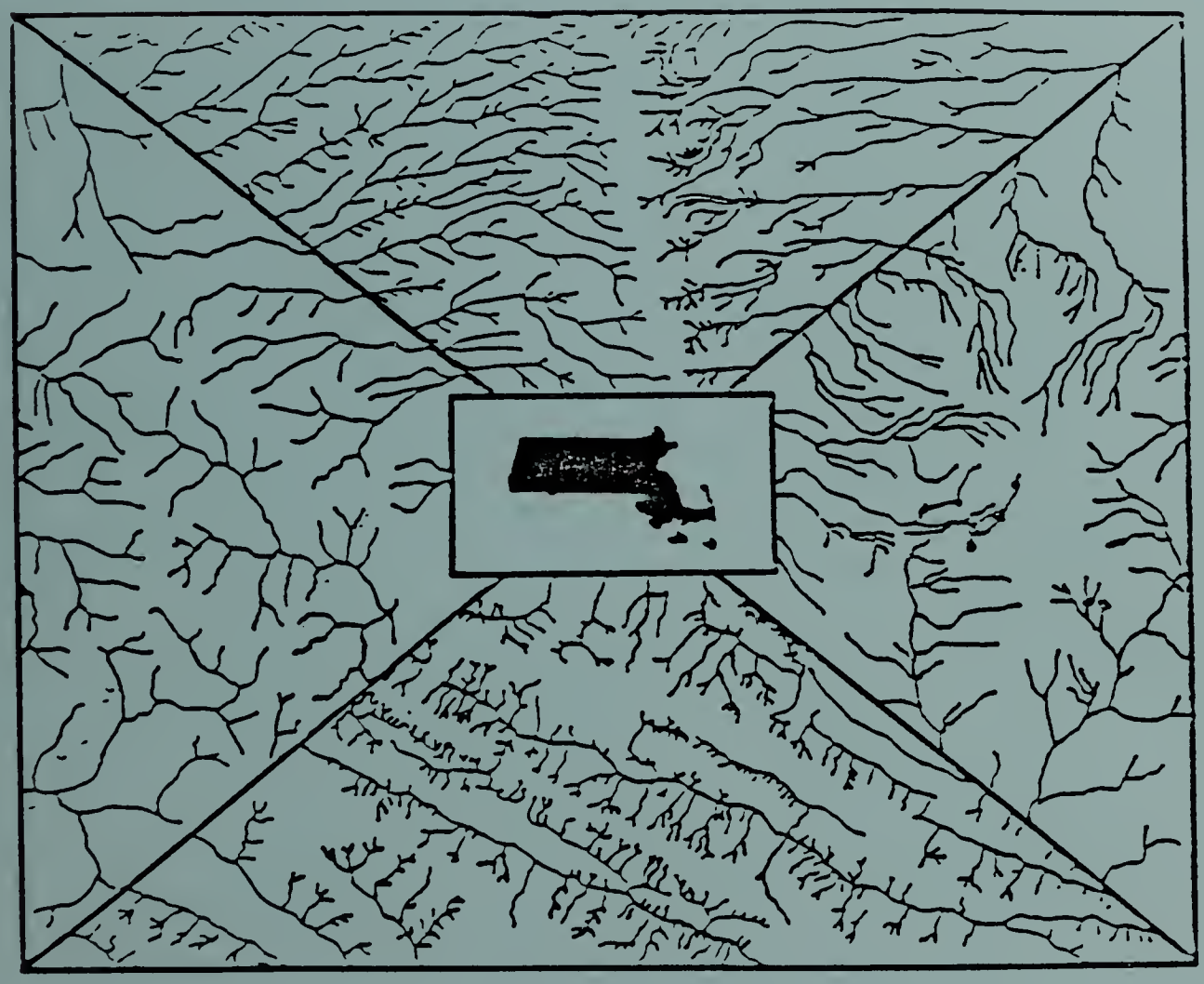
Standard Operating Procedures



River and Stream Monitoring

BASINS PROGRAM

1989

Massachusetts Department of Environmental Quality Engineering
DIVISION of WATER POLLUTION CONTROL
Neil O Leary, Acting Director

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BASINS PROGRAM

Standard Operating Procedures

River and Stream Monitoring

1989

Technical Services Branch
Massachusetts Division of Water Pollution Control
Department of Environmental Quality Engineering
Westborough, Massachusetts

Executive Office of Environmental Affairs
John P. DeVillars, Secretary

Department of Environmental Quality Engineering
Daniel S. Greenbaum, Commissioner

Division of Water Pollution Control
Cornelius J. O'Leary, Acting Director

Cover

Common Drainage Patterns

MAY 1989

Publication #15989-60-50-6-89-C.R.
Approved By: Ric Murphy, State Purchasing Agent

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INTRODUCTION

This report has been prepared in order to standardize field methods used by members of the Basin Planning Section of the Division of Water Pollution Control's Technical Services Branch. The procedures described here have been developed from accepted methods in water pollution reference manuals and from field experience of Technical Services Branch personnel. The methods outlined will be continually reviewed, and updated and/or modified as necessary.

The importance of a good water quality sampling program cannot be over-emphasized. Proper sampling procedures must be followed at all times in order to obtain representative water quality samples. Proper storage techniques must be used in order to maintain the integrity of the sample. Good field recording methods are necessary for accurate data transmission. Field personnel must follow the methods outlined in this Standard Operating Procedure to insure meaningful results for all field procedures.

I. PLANNING A WATER QUALITY SURVEY

Adequate planning is essential for a successful water quality survey. The survey coordinator must consider reasons for conducting a survey, the types of data necessary to fulfill survey objectives, and personnel and equipment available to participate in the survey.

a. Objectives

There are many reasons for conducting a water quality survey. The objectives are interrelated and cover different elements of a water quality program, from planning to enforcement. Reasons for conducting a water quality survey include the following:

1. Establish representative baseline water quality conditions;

2. Determine assimilative capacities of streams;

3. Follow effects of a particular project or activity;

4. Identify pollutant source(s);

5. Assess long term trends;

6. Allocate waste load(s); or

7. Project future water quality.

These examples of possible objectives reflect the wide range of operations that may be involved in stream studies. They emphasize the necessity of a clear definition of objectives for a particular study. The objectives should be put in writing for several reasons. The act of putting them on paper requires careful consideration of what the objectives actually should be. The written work is far less apt to be misunderstood by those involved in the operations than is a verbal statement. The written objectives should define not only the purposes of the study but also the limits, and thus should discourage the pursuit of interesting but non-essential bypaths. They fix the responsibility of those charged with supervision of the study. They provide a basis of judging the extent to which the results of the study meet the needs that justified the undertaking.

b. Review of Existing Data

Early in the planning process, the survey coordinator should review all readily available information on the stream to ascertain the existing data base, to inventory all pollutant sources, and to determine water uses. The coordinator should always review thoroughly all previous work conducted by the TSB. Additional information may be obtained from discussions with DEQE personnel in the regional offices and in the Boston Office. It is also prudent to contact the

appropriate regional planning agency and watershed council (if they exist). These groups can provide information about activities in the basin which may impact water quality as well as citizen concerns regarding sources of pollution in the watershed.

c. Field Reconnaissance

The coordinator should conduct a field reconnaissance of the survey area. If possible, the coordinator should be accompanied by persons with expertise in specific areas of the general water quality study, such as a biologist or a compliance monitoring engineer. Their input may have an important influence on the final comprehensive survey plan, such as eliminating sampling locations that may provide data of minimal value or adding locations of significant importance that may have been previously overlooked.

The survey coordinator should become thoroughly familiar with characteristics of the stream. A trip throughout the study area by boat, if the stream is deep enough, provides the best opportunity for observation. Access to the stream may be limited to bridges and roads that parallel the stream if a boat cannot be used. An overall view of the stream may be obtained from a plane or helicopter, but observation of detail from the height involved is limited. Walking usually is difficult because of undergrowth or rough terrain, and is extremely time consuming unless the stream reach is very short.

Detailed notes of observations should be made promptly, in a field book, for memory alone is not dependable. Notes should include general impressions of depths, currents, velocities, bends, widths, types of bottom, water uses, waste discharges and mixing of wastes, availability of access, and sensory evidences of pollution such as excessive plankton or attached growth, floating materials, oil, color, suspended matter, sludge deposits, gas bubbles and odor. Special attention should be paid to tentative sampling stations selected in the preliminary planning. Accessibility of stations, as well as suitability for sampling, must be considered.

d. Develop a Survey Plan

After reviewing existing data and conducting field reconnaissance, the coordinator will develop a written plan for the survey. The preliminary survey plan will summarize the survey objectives, define the scope of the sampling regime, list frequency of sample collection and the parameters to be analyzed, and outline any survey work which will be requested of other sections at the Technical Services Branch.

1. Scope of Survey

The water quality surveys conducted by the Basin Planning Section fall into three general categories:

- intensive
- synoptic
- field investigations

An intensive survey is designed to determine changing water quality conditions in a water body both spatially (along the length of the reach) and temporally (over time). A series of related sampling stations are chosen which will reflect both instantaneous changes and long term changes in water quality. Samples are manually collected at frequent intervals, usually four (4) times a day, and composited daily. These surveys are conducted for a limited period of time, usually three (3) days. Laboratory analyses are performed on the composited samples. The analyses are chosen to reflect processes which are occurring instream. It should be noted that it has been the experience of the Basin Planning Section that these samples must be manually collected. Automatic samplers are prone to theft and vandalism.

Synoptic surveys are designed to determine changing water quality conditions spatially. As with intensive surveys, a series of related sampling stations are chosen along a stream to reflect changes from introduction of pollutant loads. However, in a synoptic survey, grab samples are collected once a day. A synoptic survey is appropriate when the water quality conditions with respect to the parameters being analyzed are reasonably constant over a 24-hour period.

Intensive surveys require a major commitment of personnel and equipment. Intensive surveys give a much more complete picture of stream processes. However, a synoptic survey may provide adequate information, depending upon survey objectives. The coordinator should carefully consider the two types of surveys and decide which is appropriate.

A field investigation is conducted to provide information about the effect of a pollutant source on a river segment. This type of survey usually consists of a limited number of grab samples. Field investigations are often conducted in response to a request from one of the regional offices or as part of a permit evaluation.

2. Frequency of Sampling

The frequency of sampling is often determined by the type of sampling program. In intensive surveys, multiple samples are collected from one station throughout the day, and combined into a composite sample. Sampling runs are generally conducted at four- (4) or six- (6) hour intervals, over one or more 24-hour periods. In synoptic surveys, a single grab sample is collected at each sampling station.

Grab samples characterize water quality at the time of collection, while composite samples characterize average water quality conditions over a specified period of time. Certain analyses should be conducted only on grab samples. These include dissolved gases, residual chlorine, soluble sulfide, oil and grease, microbial parameters, organics, and pH.

3. Personnel

The coordinator should make an estimate early on as to how many personnel will be required for a survey. Synoptic surveys and field investigations can usually be run by the coordinator with one person assisting him/her.

Intensive surveys will require a number of work crews. The actual number of personnel will depend largely in the scope of the survey. However, general guidelines apply to almost any survey. Every water quality sampling crew should consist of a minimum of two (2) people. This applies to flow crews also. The potential hazards encountered in both situations does not make it worth sending out one individual, particularly on night sampling runs. One person is adequate for transporting samples to the Lawrence Experiment Station.

To get an accurate estimate of personnel needs, the coordinator must estimate the amount of work required of each survey crew. It may be necessary to conduct practice runs, in order to estimate the time required for a sampling run. The coordinator should also consider the time required to prepare for sample collection, and to process samples at the end of the run. The estimated time to conduct a run should not be significantly greater than a normal working day. If the time to conduct a run is too long, the work should be divided among additional survey crews.

4. Sampling Locations

The sample locations should be chosen carefully, always mindful of the survey objectives. Stream quality varies spatially and temporally. The coordinator should consider these differences when choosing stream locations. If sampling is being conducted to establish background or baseline conditions, stations where water is well mixed should be chosen. If sampling is being conducted to study the amount of variation in a parameter, areas where the extremes in chemical concentrations are likely to occur should be selected.

The coordinator should review and evaluate sample locations used in previous surveys. Water quality samples are often located:

a. upstream and downstream of significant discharges;

b. upstream and downstream of confluence with major tributaries;

c. upstream and downstream of significant physical changes in the river;

d. at inlets and outlets of major impoundments;

e. at major water use areas (e.g. a water supply, an area with heavy recreational use, an active fisheries area); and

f. at areas known to have critical water quality problems.

Major wastewater discharges should be sampled during intensive and synoptic surveys. The sampling has historically been conducted by the Compliance Monitoring Section personnel. The Compliance Section currently is not staffed. The wastewater discharges thus should be sampled either by TSB personnel or arrangements made for the wastewater treatment plant operator to collect the samples. The coordinator should consider which discharges will be sampled, where the process train samples will be collected, what parameters will be analyzed, and how samples will be collected (i.e., grab or composite).

5. Types of Samples

TSB personnel measure pH and temperature in the field and fix dissolved oxygen samples for analysis at Westborough. Chlorophyll a determinations are conducted at Westborough, by Biology Section personnel. All other analyses are performed at the Department's Lawrence Experiment Station. Table 1 lists parameters which are routinely requested for stream surveys. The parameters are divided into groups which have similar methods of collection and preservation. Other analyses may be available. If additional analyses are desired, the coordinator should discuss needs with laboratory personnel at the Lawrence Experiment Station.

6. Stream Flow

Water quality surveys should include stream flow data. Stream flow is one of the primary factors which determines water quality. Both natural water quality and the effects of wastewater in a stream vary as flow changes.

The survey coordinator should first check the Gazetteer of Hydrologic Characteristics of Stream in Massachusetts (USGS, Water Resources Investigation Reports 1984 for the appropriate river basin to see if there are any flow gages located in the survey area. Average daily flows are available for all U.S. Geological Survey (USGS) continuous monitoring stations. Annual flow data are published by the USGS, Water Resources Division in a publication titled "Water Resources Data Massachusetts and Rhode Island Water Year 19__." Each volume contains data for one water year, which extends from October 1 to September 30. The published data are available approximately 18 months after the end of the water year. Flow data may be obtained before the annual reports are published by contacting the USGS, 28 Lord Road, Marlborough, MA 01752. Flow data which is obtained in a relatively short span of time following a survey will be provisional. If provisional data are used in a report or a water quality analysis, it should be noted that the data are provisional.

Before a survey, the coordinator should inspect any USGS gages to see if they have staff gages. Instantaneous staff gage readings should be recorded by field personnel whenever possible during a survey period. Conversion tables which relate gage height to flow are available in-house for most USGS staff gages.

If no USGS gages are located in the survey basin, the coordinator should make provisions to have flow measurements taken during the survey. Even if there are one or more gages located in a basin, the coordinator should carefully evaluate the need for additional flow measurements.

TSB stream flow measurement procedures are contained in Chapter III.

7. Participation of Other TSB Sections

Other TSB sections are available to assist the basin planning section conduct river surveys. Biology section personnel may be available to perform a number of biological assessments, which can be used to evaluate water quality. Members of the lakes section can assist in evaluations of river impoundments as well as lakes and ponds in a river basin. The survey coordinator must begin preliminary discussions about assistance on surveys from other sections well in advance of the actual date of a water quality survey.

The written survey plan should address the items discussed in the preceding paragraphs. The basin planning section does not follow a standardized outline format. However, at a minimum, the survey plan should discuss

- reasons for and objectives of a survey
- number and location of sampling stations
- analyses to be conducted
- frequency of sampling
- personnel, vehicle, and equipment needs.

Examples of outlines for intensive and synoptic surveys are included as Appendices A and B.

TABLE 1

TYPES OF WATER QUALITY ANALYSES

WATER COLUMN

CHEMICAL	NUTRIENT	BACTERIA	METALS	ORGANICS	OTHER
BOD_5	Total P	Fecal Coliform	Al	Volatile Scan	Oil & Grease
Total Solids	Ortho P	Total Coliform	Ag	Phenols	
Suspended Solids	TKN		Cd	Base Neutral Extractables	
Alkalinity	NH_3-N		Cr	Acid Extractables	
Chloride	NO_3-N		Cu	PCB's	
Turbidity	Hardness		Fe	PAH's	
Color	COD		Hg	Pesticides	
			Mg		
			Mn		
			Ni		
			Pb		
			Zn		

SEDIMENTS

PHYSICAL and NUTRIENTS		METALS	ORGANICS	OTHER
%VS	Total P	Al	Volatile Scan	Oil & Grease
	Ortho P	Ag	PCB's	
	TKN	Cd	PAH's	
	NH_3-N	Cr	Pesticides	
	NO_3-N	Cu		
		Fe		
		Hg		
		Mg		
		Mn		
		Ni		
		Pb		
		Zn		

II. SURVEY PREPARATIONS

Adequate preparation is essential for a successful survey. Whether a person is going to conduct a single-site field investigation or a basin-wide survey, good survey preparation will result in a much smoother survey and in better data collection.

The coordinator should read through all the elements listed in this section, and note those which apply to his/her survey. The coordinator should then set up a schedule to get all the tasks completed in advance of the survey. New personnel should discuss their survey plans with experienced staff.

a. Logistics

If the river to be surveyed is located at a considerable distance from the TSB, the coordinator should consider providing lodging for personnel. Funds are generally available for this purpose. If travel to the river adds a significant time to the personnel's work day and/or personnel will be working at late hours, it is usually prudent to arrange for lodging at the site of the survey.

Approximately two to three months before the survey the coordinator should obtain a preliminary approval, through the TSB Administration section, for lodging. The coordinator should locate convenient living quarters near the survey area. The coordinator should then write a memorandum to the Administration section which contains the dates of survey, the number of people requiring lodging, and the total cost. More information about obtaining funding for surveys requiring lodging is in Appendix C.

If a survey is not based out of the Westborough offices, provisions must be made for on-site laboratory space. Often, arrangements can be made with treatment plant operators to use space at the wastewater treatment plants. Arrangements should be made well in advance of the survey. It usually is necessary to use these facilities after the normal working hours. Make certain that personnel will be able to get into the field laboratory as required. Whenever using someone else's facilities, be considerate of employees working there. Instruct survey personnel to keep the working area as clean as possible. Be extremely careful when working with acids or other materials which could damage the field laboratory.

If personnel will be required to travel out-of-state for a survey, approval for such travel must be obtained before the survey. All travel outside of the Commonwealth of Massachusetts requires prior approval, even when no travel funds are requested. The lack of such approval can result in loss of salary, as well as any insurance coverage protection usually afforded to state workers (e.g., Workmen's Compensation). To get approval for out-of-state travel, the coordinator should notify the Administration section of the need to go out of state a minimum of three to four weeks before the survey will be conducted. Information about approval for out-of-state travel is contained in Appendix D.

b. Equipment

The coordinator should check to see that all required equipment is available for use during the survey that all equipment is in working order, and that there are adequate supplies to last through the survey. Table 2 lists the equipment most often used in water quality surveys. This list is not exhaustive; additional items may be necessary for survey.

c. Boats

The TSB has three Boston Whalers, and several prams and canoes which can be used for survey. In large river systems, it is often preferable to sample from a boat. Boat use is supervised by the Administration Section. The coordinator should discuss any needs for boat usage with the Administration Section at the beginning of the survey season.

d. Sample Containers

Water quality samples must be collected in the proper containers. A survey coordinator must make sure that there are enough of the proper sample bottles for each type of sample to be collected during the survey, and that all bottles are properly prepared. Table 3 summarizes the type of container used for sample collection, and the procedures for preparing collection bottles prior to use.

More than one type or size of container may be acceptable for sample collection. Table 3 lists the containers used by the Basin Planning Section for various parameters. If a survey coordinator wishes to use a different type of container for sample collection, he/she should check with the Lawrence Experiment Station to be certain that the sample container is made of the proper material and that it will contain an adequate volume of sample for the required analyses.

e. Sample Tags

Water quality samples should be clearly tagged at the time of collection. Dissolved oxygen samples are tagged with a manila tag on which station number, military time, and water temperatures are marked. Chemical, nutrient, metal, organics, and bacteria samples are tagged with waterproof tags. Information on the tags include station number, station location, name of receiving water, type of sample (grab or composite), purpose of test, and analyses requested. Sample collection tags used by the Basin Planning Section are shown in Figure 1 (Page 16).

It can take a great deal of time to fill out a complete set of tags for a survey. Therefore, tags should be prepared prior to a survey rather than during the field work. All information must be legible.

f. Preliminary Survey Meeting and Dry Run

A coordinator of an intensive survey will have a number of persons working for him/her during the survey. The coordinator should meet with all survey personnel a few days before the survey for a briefing

on the survey plan. In addition, experienced personnel not assigned to the study should be asked to attend the briefing to offer constructive comments on the field plans.

At the briefing session definite assignments of responsibilities to specific individuals for various phases of the survey should be made. Written personnel assignments and copies of the study plan should be distributed to all survey personnel. The overall study plan as well as individual assignments and responsibilities should be discussed to ensure that there are no misunderstandings or oversights regarding the survey.

The coordinator should take at least one member of each sampling crew on a dry run of the sampling route. The coordinator should show each sampling site to crew members, as well as the route to follow from station to station. Stations should be marked or otherwise identified to ensure sample collection at the proper points. The sampling station may be marked with paint on the road surface at the point of collection. The coordinator should explain to all persons the exact spot where the sample should be collected (i.e., the upstream or downstream side of a bridge). The coordinator should show personnel the route to all stations, and give each crew a set of maps on which all sample stations are clearly marked.

Arrangements for communication with all individuals should be established. Telephone numbers at which individuals can be reached day or night should be listed at a central location, such as the laboratory.

It is the responsibility of the coordinator to see that all survey crew members are properly instructed in sample collection methods and use of field meters.

g. Notification of Lawrence Experiment Station

It is important that the Lawrence Experiment Station be notified of water quality survey plans prior to delivery of samples. The head of the Basin Planning Section prepares a weekly memorandum to the LES Chief of Laboratory which lists the samples which will be delivered from all sections of the TSB in the upcoming week.

The survey coordinator should submit to the head of the Basin Planning Section a list of all water quality samples to be collected during the survey. A monitoring request form should be completed and submitted 10 days prior to the survey. A copy of the monitoring request form is included in this report as Appendix E.

If special analyses or collection/preservation techniques are required, or if an extraordinary number of samples will be collected, the coordinator should discuss survey plans with the chief of laboratory as far in advance of the survey as possible.

TABLE 2

EQUIPMENT AND SUPPLIES FOR WATER QUALITY SURVEY

1. Vehicles

2. Equipment

Coolers

Buckets (plastic and/or metal) with sufficient length of rope or water samplers

Thermometer

pH meter with buffers

D.O. kit - BOD bottles

Reagents #1 and #2

Manilla tags

Cover (to keep samples out of light)

Field book

Maps with sampling locations

Pencils

Sample bottles

Preserving bottles - 1:1 H_2SO_4 for nutrient samples

1:1 HNO_3 for metals samples

Waterproof sample tags

Watch

Gloves

Saran wrap

Distilled water

First aid kit

Safety glasses

Rain gear

Flashlight

Safety vests

Traffic cones

3. Supplies

Thiosulfate solution (0.0375N)

Starch solution

Concentrated H_2SO_4, HNO_3, HCl (reagent grade)

1:1 H_2SO_4 to fix nutrient samples

1:1 HNO_3 to fix metals samples

Ice

TABLE 3

CONTAINER TYPE FOR SAMPLE COLLECTION

WATER COLUMN

SAMPLE TYPE	CONTAINER	PREPARATION	NOTES
Dissolved Oxygen	300 ml glass BOD bottle with glass stopper	Rinse well with tap water after use	° No air in bottle ° Cover to keep out of sunlight
Bacteria	Sterile 200 ml glass bottle with rubber lined screw top	As provided by LES	° Fill to collar ° Use bottles with thiosulfate for chlorinated samples
Chemical (BOD, SS, TS, etc.)	½ gallon glass bottle with screw top	Rinse with distilled water	--
Nutrients (includes COD, hardness)	16 oz. widemouth glass bottle with teflon screw top	Rinse with distilled water	--
Metals	16 oz. widemouth glass bottle with teflon screw top	Rinse with (1+1) HNO_3, tap water, (1+1) HCL, twice with distilled deionized water	--
Chlorophyll a, Algal Identification	32 oz. polyethylene bottle with screw top	Rinse with distilled water	--
Microtox™	16 oz. widemouth glass bottle with teflon screw top	Rinse twice with distilled water	--
Volatile Organic	60 ml screw top bottle with teflon lined septum	As provided by LES	° No head space duplicate samples collected at each station ° No air bubbles in bottle

TABLE 3 (CONTINUED)

SAMPLE TYPE	CONTAINER	PREPARATION	NOTES
Oil and Grease	½ gallon glass bottle with teflon lined screw top (acid bottles)	Rinse with 30% H_2SO_4 and then rinse 3 times with distilled water	--
PCB's; Acid, Base-Neutral Extractables	1 gallon glass bottle with screw top	Rinse with distilled water, then with acetone then with hexane. Allow to dry under hood, then cap.	° Teflon lined cap or cover with aluminum foil before capping

TABLE 4

CONTAINER TYPE FOR SAMPLE COLLECTION

SEDIMENT

SAMPLE TYPE	CONTAINER	PREPARATION	NOTES
Nutrient	16 oz. widemouth glass bottle with screw top	Rinse with distilled water	--
Metals	16 oz. widemouth glass bottle with screw top	Rinse with 30% HNO_3, then 3 times with distilled water	--
PCB's or PAH's	16 oz. widemouth glass bottle with screw top	Rinse with distilled water, then with acetone then with hexane. Allow to dry under hood, then cap	Cover with aluminum foil before capping
Volatile organic	60 ml screw top bottle with teflon lined septum	As provided by LES	Duplicate samples collected at each station

Figure 1

WATER QUALITY SAMPLING TAGS

USED BY DWPC/TSB BASIN PLANNING SECTION

Massachusetts Department of
Environmental Quality Engineering
LAWRENCE EXPERIMENT STATION

TOWN/CITY _____

SOURCE _____

STATION(Location) _____

COLLECTOR _____

DATE _____ TIME _____

TYPE OF SAMPLE _____

PURPOSE OF TEST: _____

ANALYSES REQUIRED TP, TKN, NH_3, NO_3, Hard.

REMARKS: Fixed with H_2SO_4

Authorized by DWPC/TSB
WESTBORO

Massachusetts Department of
Environmental Quality Engineering
LAWRENCE EXPERIMENT STATION

TOWN/CITY _____

SOURCE _____

STATION(Location) _____

COLLECTOR _____

DATE _____ TIME _____

TYPE OF SAMPLE _____

PURPOSE OF TEST: _____

ANALYSES REQUIRED Alk., TS, SS, Cl, BOD_5, Turb.

REMARKS: _____

Authorized by DWPC/TSB
WESTBORO

Massachusetts Department of
Environmental Quality Engineering
Lawrence Experiment Station

City/Town _____ Date _____

Sample
Source:

Analysis
Requested:

Preservative Used?

Bottle ID:

Chain of Custody Yes No

Time _____ Temp _____ Collector _____

City/Town _____ Date _____

Sample
Source:

Analysis
Requested:

Preservative Used?

Bottle ID:

Chain of Custody Sample? Yes No

Time _____ Temp _____ Collector _____

PLEASE COMPLETE TOP & BOTTOM OF TAG
(Additional Remarks Reverse Side)

Authorized by DWPC/TSB
WESTBORO

Massachusetts Department of
Environmental Quality Engineering
LAWRENCE EXPERIMENT STATION

TOWN/CITY _____

SOURCE _____

STATION(Location) _____

COLLECTOR _____

DATE _____ TIME _____

TYPE OF SAMPLE _____

PURPOSE OF TEST: _____

ANALYSES REQUIRED Ag, Al, Cd, Cr, Cu, Fe, Ni, Pb, Zn

REMARKS: Fixed with HNO_3

Authorized by DWPC/TSB
WESTBORO

Massachusetts Department of
Environmental Quality Engineering
LAWRENCE EXPERIMENT STATION

TOWN/CITY _____

SOURCE _____

STATION(Location) _____

COLLECTOR _____

DATE _____ TIME _____

TYPE OF SAMPLE _____

PURPOSE OF TEST _____

ANALYSES REQUIRED _____

REMARKS: _____

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WESTBORO

MASS. DEQE/LES

Town/City _____

Source _____

Collector _____

Station Number _____ Bottle Number _____

Date _____ Time _____

Analyses- fecal coliform

Remarks _____

Bact. Lab # _____

WPC Lab # _____

Authorized by DEQE/DWPC TSB

III. CONDUCTING A WATER QUALITY SURVEY

All personnel must be familiar with the proper field procedures for the collection of water quality samples. Improperly collected samples cannot be analyzed and, thus, negate considerable effort and cost expended in their collection.

a. Water Column Samples

1. Collection

Water samples are generally collected using a bucket or by hand. The bucket should be rinsed once with ambient water prior to collecting the samples. In large rivers or impoundments, Kemerer or Van Dorn water samplers may be used. The samples should be collected such that a minimum amount of oxygen is added to the sample.

Sample bottles at each station are filled in the following order:

- bacteria
- dissolved oxygen
- pH and temperature are measured using meter and thermometer
- chemical
- nutrient
- metal

Organic samples (VOA, PCB, PAH, acid extractables, base-neutral extractables) are collected with a metal collection device or are sampled directly from the water body into the sample container.

2. Preservation

Temperature and pH are determined in the field, using a thermometer and a pH meter. Dissolved oxygen samples are fixed in the field and the values are determined at the Westborough office. The method for oxygen determination and the laboratory sheet used for dissolved oxygen determinations are included in Appendices F and G. pH is determined using a meter. The methods for use of the meter are contained in the user's manual. All personnel should read the manual thoroughly before using the meter. If not certain about how to use the meter correctly, ask another member of the staff for instructions. The meter must be calibrated using two buffers which bracket the anticipated range of field measurements prior to going out in the field. At each station, the meter must be recalibrated with a single buffer (pH = 7.0).

All other samples are preserved and transported to Lawrence Experiment Station for analysis. Methods of preservation are listed in Table 5. Table 5 also lists the holding time for all parameters. If holding times are exceeded, samples will deteriorate and subsequent analyses will not be truly represen-

tative of the condition sampled. Surveys should be conducted such that samples can be transported to LES within the sample holding times.

3. Sample Tags

All samples must be clearly marked with a waterproof tag listing sample station and location, date, collector, analyses required, and preservation method.

4. Field Notes

Personnel should always carry a field notebook. Field notes should be taken on all surveys.

5. Dissolved Metal Samples

For certain investigations, it is desirable to know the portion of metals which are in the dissolved form. TSB personnel are responsible for doing the necessary filtration to determine the dissolved fraction before transporting the samples to Lawrence Experiment Station. The procedure for preparing dissolved metals samples is included in Appendix F.

b. Sediment Samples

There are three broad classifications of sediment collecting devices: corers, grabs, and dredges. Corers generally produce the least disturbed samples; grabs collect larger surface samples; and dredges collect larger, well-mixed samples that are considered qualitative. The basin planning section generally uses a 9-inch Ponar dredge sampler for collecting sediment samples.

Sediment samples are placed in 16-ounce widemouth glass bottles with screw tops. No fixatives are necessary for these samples. They should be carefully tagged, in a similar method as water column samples.

When sediment samples are to be analyzed for PCB's or PAH's, special sample procedures must be observed. Sample containers must be rinsed with acetone and then with hexane. Prepared bottles may be available from LES. The dredge must also be cleaned with acetone and hexane before using, and between samples. The waste solvent from the field must be collected and brought back to the Westborough office for disposal. PCB and PAH sediment sample bottles must be capped with a teflon lined cap, or covered with aluminum foil before being capped.

Volatile organic samples cannot be taken on a survey run when PCB or PAH sediment samples are collected. The solvents used to wash the dredge will contaminate any volatile organic samples.

TABLE 5

REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES*

PARAMETER NO./NAME	CONTAINER[1]	PRESERVATION[2,3]	MAXIMUM HOLDING TIME[4]
Table 1A - Bacterial Tests:			
1-4. Coliform, fecal and total	P.G.	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	6 hours
5. Fecal streptococci	P.G.	do**	do
Table 1B - Inorganic Tests:			
1. Acidity	P.G.	Cool, 4°C	14 days
2. Alkalinity	P.G.	do	do
4. Ammonia	P.G.	Cool, 4°C, H_2SO_4 to pH<2	28 days
9. Biochemical oxygen demand	P.G.	Cool, 4°C	48 hours
11 Bromide	P.G.	None required	28 days
14. Biochemical oxygen demand, carbonaceous	P.G.	Cool, 4°C	48 hours
15. Chemical oxygen demand	P.G.	Cool, 4°C, H_2SO_4 to pH<2	28 days
16. Chloride	P.G.	None required	do
17. Chlorine, total residual	P.G.	do	Analyze immediately
21. Color	P.G.	Cool, 4°C	48 hours
23-24. Cyanide, total and amenable to chlorination	P.G.	Cool, 4°C, NaOH to pH>12, 0.6g ascorbic acid[5]	14 days
25. Fluoride	P	None required	28 days
27. Hardness	P.G.	HNO_3 to pH<2, H_2SO_4 to pH<2	6 months
28. Hydrogen ion (pH)	P.G.	None required	Analyze immediately
31, 43. Kjeldahl and organic nitrogen	P.G.	Cool, 4°C, H_2SO_4 to pH<2	28 days

* Federal Register, 1984.
** = ditto

Note: superscripts are found on Pages 22-23

TABLE 5 (CONTINUED)

PARAMETER NO./NAME	CONTAINER[1]	PRESERVATION[2,3]	MAXIMUM HOLDING TIME[4]
Metals:[7]			
18. Chromium VI	P.G.	Cool, 4°C	24 hours
35. Mercury	P.G.	HNO_3 to pH<2	28 days
3, 5-8, 10, 12, 13, 19, 20, 22, 26, 29, 30, 32-34, 36, 37, 45, 51, 52, 58-60, 62, 63, 70-72, 74, 75. Metals, except chromium VI and mercury	P.G.	do	6 months
38. Nitrate	P.G.	Cool, 4°C	48 hours
39. Nitrate-nitrite	P.G.	Cool, 4°C, H_2SO_4 to pH<2	28 days
40. Nitrite	P.G.	Cool, 4°C	48 hours
41. Oil and grease	G	Cool, 4°C, H_2SO_4 to pH<2	28 days
42. Organic carbon	P.G.	Cool, 4°C, HCl or H_2SO_4 to pH<2	do
44. Orthophosphate	P.G.	Filter immediately, Cool, 4°C	48 hours
46. Oxygen, dissolved probe	G bottle and top	None required	Analyze immediately
47. Winkler	do	Fix on site and store in dark	8 hours
48. Phenols	G only	Cool, 4°C, H_2SO_4 to pH<2	28 days
49. Phosphorus (elemental)	G	Cool, 4°C	48 hours
50. Phosphorus, total	P.G.	Cool, 4°C, H_2SO_4 to pH<2	28 days
53. Residue, total	P.G.	Cool, 4°C	7 days
54. Residue, filterable	P.G.	do	48 hours
55. Residue, nonfilterable (TSS)	P.G.	do	7 days
56. Residue, settleable	P.G.	do	48 hours
57. Residue, volatile	P.G.	do	7 days
61. Silica	P	do	28 days
64. Specific conductance	P.G.	do	do
65. Sulfate	P.G.	do	do
66. Sulfide	P.G.	Cool, 4°C add zinc acetate plus sodium hydroxide to pH>9	7 days
67. Sulfite	P.G.	None required	Analyze immediately
68. Surfactants	P.G.	Cool, 4°C	48 hours
69. Temperature	P.G.	None required	Analyze
73. Turbidity	P.G.	Cool, 4°C	48 hours

PARAMETER NO./NAME	CONTAINER[1]	PRESERVATION[2,3]	MAXIMUM HOLDING TIME[4]
Table 1C - Organic Tests:[8]			
13, 18-20, 22, 24-28, 34-37, 39-43. 45-47, 56, 66, 88, 89, 92-95, 97. Purgeable hydrocarbons	G. Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	14 days
6, 57, 90. Purgeable aromatic hydrocarbons	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], HCl to pH2[9]	do
3, 4. Acrolein and acrytonitrite	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], Adjust pH to 4-5[10]	do
23, 30, 44, 49, 53, 67, 70, 71, 83, 85, 96. Phenols	G. Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction 40 days after extraction
7, 38. Benzidines[11]	do	do	7 days until extraction
14, 17, 48, 50-52. Phthalate esters	do	Cool, 4°C	7 days until extraction 40 days after extraction
72-74. Nitrosamines[11,14]	do	Cool, 4°C, store in dark. 0.008% $Na_2S_2O_3$[5]	do
76-82.11 PCBs acrylonitrite	do	Cool, 4°C	do
54, 55, 65, 69. Nitroaromatics and isophorone[11]	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5] store in dark	do
1, 2, 5, 8-12, 32, 33, 58, 59, 64, 68, 84, 86. Polynuclear aromatic hydrocarbons[11]	do	do	do
15, 16, 21, 31, 75. Haloethers	do	Cool, 4°C, 0.008% $Na_2S_2O_3$	do
29, 35-37, 60-63, 91. Chlorinated hydrocarbons[22]	do	Cool, 4°C	do
87. TCDD[11]	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	do
Table 1D - Pesticides Tests:			
1-70. Pesticides	do	Cool, 4°C, pH 5-9[15]	do
Table 1E - Radiological Tests:			
1-5. Alpha, beta and radium	P.G.	HNO_3 to pH<2	6 months

NOTES FOR TABLE 5

1. Polyethylene (P) or Glass (G)

2. Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

3. When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table II, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater): Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

4. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator under § 136.3(e). Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability. See § 136.3(e) for details.

5. Should only be used in the presence of residual chlorine.

6. Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

7. Samples should be filtered immediately on-site before adding preservative for dissolved metals.

NOTES FOR TABLE 5 (CONTINUED)

8. Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

9. Sample receiving no pH adjustment must be analyzed within seven days of sampling.

10. The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

11. When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re the requirement for thiosulfate reduction of residual chlorine), and footnotes 12, 13 (re: the analysis of benzidine).

12. If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 $\pm$ 0.2 to prevent rearrangement to benzidine.

13. Extracts may be stored up to seven days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

14. For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$, and adjust pH to 7-10 with NaOH within 24 hours of sampling.

15. The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

IV. FLOW MEASUREMENT

a. Instream Flow Measurements

The first step in making a current-meter measurement is to select a reach of stream containing the following characteristics:

- A straight reach with the threads of velocity parallel to each other.
- Stable stream-bed free of large rocks, weeds, and protruding obstructions such as piers, which would create turbulence.
- A flat stream-bed profile to eliminate vertical components of velocity.

It is usually not possible to satisfy all of these conditions. Select the best possible reach using these criteria and then select a cross section.

After the cross-section has been selected, determine the width of the stream. String a tag line or measuring tape for measurements. String the line at right angles to the direction of flow to avoid horizontal angles in the cross-section. Next determine the spacing of the verticals, generally using about 25 to 30 partial sections. With a smooth cross-section and good velocity distribution, fewer sections may be used but this is not encouraged. Space the partial sections so that no partial section has more than 10% of the total discharge in it. The ideal measurement is one in which no partial section has more than 5% of the total discharge in it, but this is very seldom accomplished when 25 partial sections are used. Equal widths of partial sections across the entire cross section are not recommended unless the discharge is well distributed. Make the width of the partial sections less as depths and velocities become greater.

After the cross section has been selected and the stationing determined, assemble the appropriate equipment for the current-meter measurement and prepare the measurement note sheets to record the observations. For each discharge measurement record the following information on the standard flow sheet (Figure 2):

1. Name of stream and location to correctly identify the established gaging station; or name of stream and exact location of site for a miscellaneous measurement.
2. Date, field crew members, type of meter suspension, and meter number.
3. Time measurement is started using military time.
4. Bank of stream that is the starting point.

5. Control conditions.

6. Gage heights and corresponding times.

7. Water Temperature.

8. Weather conditions for day of survey, and note any significant antecedent storm events.

9. Other pertinent information regarding the accuracy of the discharge measurement and conditions which might affect the stage-discharge relation.

Identify the stream bank by either LEW or REW (left edge of water or right edge of water, respectively, when facing upstream). Record the time in the notes periodically, during the course of the measurement. When the measurement is completed, record the time and the bank of the stream where the section ends.

After the equipment and the note sheet have been readied, begin the measurement. Indicate on the note sheet the distance from the initial point to the edge of the water. Measure and record the depth at the edge of water.

After the depth is known and recorded, determine the method of velocity measurement. Normally the two-point method or the 0.6-depth method is used (i.e., for flow depth $\leq$3 feet, velocity is measured at 0.6 (depth) of water; for flow depth >3 feet, velocity measurements are taken at 0.2 (depth) and at 0.8 (depth) and averaged). Compute the setting of the meter for the particular method to be used at that depth. Record the meter position (as 0.8, 0.6, 0.2, ...). After the meter is placed at the proper depth, permit it to become adjusted to the current before starting the velocity observation. The time required for such adjustment is usually only a few seconds if the velocities are greater than 1 fps. For lower velocities, particularly if the current meter is suspended by a cable, a long period of adjustment is needed. If the meter has a digital readout, record the velocity displayed. If a pygmy meter is being used for which the number of revolutions (clicks) must be counted, a count should be taken for a period of 40-70 seconds. Start the stopwatch simultaneously with the first signal or click, counting "zero," not "one." End the count on a convenient number given in the meter rating table column heading. Stop the stopwatch on that count and read the time to the nearest second, or to the nearest even second if the hand is on a half-second mark. Record the number of revolutions and the time interval.

If the velocity is to be observed at more than one point in the vertical, determine the meter setting for the additional observation, time the revolutions, and record the data. Move to each of the verticals and repeat this procedure; record the distance from initial point, depth, meter-position depth, revolutions, and time interval, until the entire cross-section has been traversed.

If the direction of flow is not at right angles to the cross-section, find the velocity vector normal to the section. Measure the cosine of the horizontal angle by holding the note sheet in a horizontal position with the point of origin (0) on the left edge of the note sheet over the tag line, bridge rail, or any other feature parallel to the cross-section. With the long side of the note sheet parallel to the direction of flow, the tag line or bridge rail will measure the value of the cosine of the angle a on the top, bottom, or right edge of the note sheet. Multiply the measured velocity by the cosine of the angle to determine the velocity component normal to the measuring section.

b. Rod Methods

Current meter measurements by wading instream are preferred, if conditions permit. Wading measurements offer the advantage over measurements from bridges in that it is usually possible to select the best of several available cross-sections for the measurement.

The Division employs two (2) types of current meters for instream flow measurements--(1) Price-pygmy meter, (2) Digital current meter. Both meters are of the type that is attached to a supporting rod. The Price-pygmy meter is a bucket wheel device (similar to an anamometer) that rotates in flowing water which is connected to a cam device for determining the number of revolutions. As the bucket wheel rotates, an electrical contact is closed on either a single-contact cam, or a penta gear. If a headset is attached to the single contact post, a signal is produced each time the bucket wheel completes a revolution. If the headset is connected to the penta-contact post, a signal is produced once every five revolutions. The penta-contact is very useful in streams with high velocities (e.g., >1.0 fps).

The velocity at the point of the current meter is measured by counting the number of signals (revolutions in a specified time inverval). Thus, a standard piece of equipment accompanying the use of a current meter is a stopwatch. Each meter is calibrated by the supplier and an equation for the relationship between velocity and revolutions per unit time derived. For the Price meters, the meter is supplied with a rating table which shows the velocity for a given number of revolutions in a given time interval. The user would be well advised to memorize the "stop counts" in the columns of the rating table. Stopping the count at some intermediate number of revolutions (27, for example) negates the use of the table and requires the use of the equation to calculate the velocity.

A Weathermeasure digital current meter is also available for instream flow measurements. It too is a rod mounted device and

requires the same transect procedures as the pygmy meter. The advantages of this meter are that it is virtually maintenance free and there are no conversion tables involved. Flow readings are instantaneously provided on a digital display in either feet per second (fps) or meters per second (mps). However, velocity is not integrated over time so the user must approximate the tenths or hundredths readings over a short interval.

The TSB also owns a Current Meter Digitizer (CMD) which can be used for instream flow measurements. The CMD is a velocity-measuring microprocessor-controlled instrument. The instrument will count revolutions for a minimum of 40 seconds, calculate the velocity from the standard rating table for the type of meter being used, and display the value. Time, revolutions and velocity can be determined at each position.

The following procedures should be followed when making an instream flow measurement regardless of which type of meter is used.

1. Stand in a position that least affects the velocity of the water passing the current meter. This position is usually obtained by facing the bank, with the water flowing against the side of the leg. Holding the wading rod at the tag line, stand from 1 to 3 inches downstream from the tag line and 18 inches or more from the wading rod. Avoid standing in the water if feet and legs would occupy a considerable percentage of the cross section of a narrow stream. In small streams where the width permits, stand on a plank or other support rather than in the water.

2. Keep the wading rod in a vertical position and the meter parallel to the direction of flow while observing the velocity. If the flow is not at right angles to the tag line, measure the angle coefficient carefully.

3. Water depth is measured using the support rod. The rod is marked in 0.1 foot increments. Depth readings should be made before each velocity measurement.

c. Cable Methods

When a stream cannot be waded, bridges may be used to obtain current-meter measurements. Many measuring sections under bridges are satisfactory for current-meter measurements.

No set rule can be given for choosing between the upstream or downstream side of the bridge when making a discharge measurement.

The advantages of using the upstream side of the bridge are:

1. Hydraulic characteristics at the upstream side of bridge openings usually are more favorable.

2. Approaching drift can be seen and be more easily avoided.

3. The streambed at the upstream side of the bridge is not likely to scour as badly as at the downstream side.

The advantages of using the downstream side of the bridge are:

1. Vertical angles are more easily measured because the sounding line will move away from the bridge.

2. The flow lines of the stream may be straightened out by passing through a bridge opening with piers.

Whether to use the upstream side or the downstream side of a bridge for a current-meter measurement should be decided individually for each bridge after considering the factors mentioned above and the physical conditions at the bridge, such as location of the walkway, traffic hazards, and accumulation of trash on piles and piers.

Use a sounding reel supported by a bridge board to suspend the current meter and sounding weight from bridges.

Keep equipment several feet from piers and abutments if velocities are high. Estimate the depth and velocity next to the pier or abutment on the basis of the observations at the vertical nearest the pier.

If there are piers in the cross section, it is usually necessary to use more than 25-30 partial sections to get results as reliable as those from a similar section without piers. Piers will often cause horizontal angles that must be carefully measured. Piers also cause rapid changes in the horizontal velocity distribution in the section.

The Price type-AA current meter is generally used when making discharge measurements from a bridge. The depth is measured by using a sounding reel and the velocity is measured by setting the meter at the proper position in the vertical.

Velocity measurements are made in the same manner as with the pygmy meter--x number of revolutions (clicks) counted for a time interval between 40 and 70 seconds. Conversion tables are used to obtain the point velocity. Please note that there are separate tables for the pygmy and Price meters. Tables are clearly marked but be sure to use the correct table with the corresponding meter.

The Stevens sounding reel is equipped with a computing depth indicator. To use the computing spiral, set the indicator

(handle pulls out to adjust indicator) when the center of the current meter rotor (cups) is at the water surface. Lower the sounding weight (lead sinker) and meter until the weight touches the streambed. A 30 C.75 suspension is used which requires that 8 inches or 0.75 feet is added to the depth indicator reading to obtain the total water depth. If, for example, the indicator reads 18.0 feet when the sounding weight touches bottom, the actual depth would be 18.75 feet. To move the meter to the 0.8-depth observation position, simply raise the weight and meter until the hand on the indicator is pointing to 15.0 feet (18.75 x 0.8 = 15.0). To set the meter at the 0.2-depth position, raise the weight and meter until the hand on the indicator is pointing to 3.75 feet.

The Weathermeasure Digital Flow meter is the same device used in the rod method. The unit can be substituted for the Price meter when using the bridge-board equipment. The advantages of this device are:

a) Less equipment must be set up.

b) Velocity measurements are read directly.

The same procedures as described for the Price meter with regard to number of partial cross-sections, measurement of depths, and operation and maintenance apply to the Digital meter also.

All data are to be recorded in the same manner as described for the rod-type water current measurements.

d. Flow Data Calculations

There are two (2) methods approved by the USGS for computing discharges from measurements made by current meters: 1) the mid-section method, and 2) Simpson's parabolic rule. Both are based on the summation of discharges of elementary areas. The midsection method is employed by the Division in calculating stream flows.

In the midsection method the depth and mean velocity are measured for each of a number of verticals along the cross-section as described previously in this section. The depth at each vertical is applied to a sectional width which extends halfway to the preceding vertical and halfway to the following vertical to develop a cross sectional area. The product of the measured mean velocity at a vertical and the corresponding cross sectional area gives the discharge for the elementary area. The summation of all the elementary discharges gives the total discharge. When using the two-point method of determining velocities, the formula for computing the discharge of an elementary area by the midsection method is:

$$q = \frac{V_1 + V_2}{2} \left[\frac{(L_2 + L_1) + (L_3 + L_2)}{2} \right] d_2$$

Where:

L_1, L_2 and L_3 = distances in feet from the initial point, for any three consecutive verticals

V_1 and V_2 = velocities in feet per second (fps) at 0.2 and 0.8 of the water depth, respectively, at vertical L_2

d_2 = water depth in feet at vertical L_2

q = discharge in second-feet through section of average depth d_2

The total discharge for the cross-section is the sum of all the elementary discharges or:

$$Q = q_i = (\bar{V}_i \times L_i \times d_i)$$

e. Flow Equipment Care

Flow equipment is very sensitive and delicate and must be handled carefully. After each use the equipment should be dried completely to prevent rusting, and the rotating bucket wheel device pivot should be oiled occasionally. The rotating bucket wheel device has a sturdy carrying case to hold the wheel and prevent any damage.

TABLE 6

EQUIPMENT LIST FOR FLOW MEASUREMENT

Rod

Pygmy meter

Digitizer meter

Headphones

Stop watch

Measuring tape

2 shovels

Clipboard

Pencil

Discharge measurement forms

Boots

Machete

Watch

Rating tables

Small screwdriver

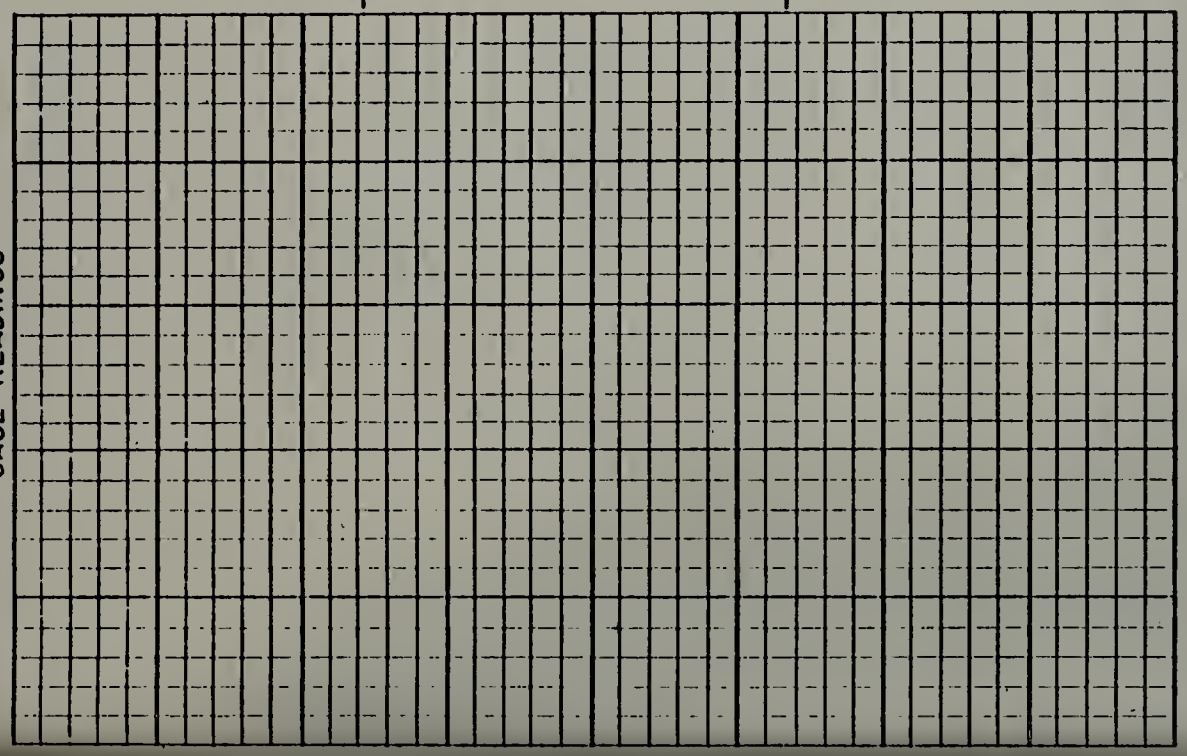
Insect Repellent

Rain Gear

Extra Batteries

GAGE READINGS

Time	Gage Height	Discharge (cfs)



COMMONWEALTH OF MASSACHUSETTS
DIVISION OF WATER POLLUTION CONTROL
WATER QUALITY SECTION

DISCHARGE MEASUREMENT NOTES

Station No. TH 11

Station Location Ten Mile R. Tiffany St. Attleboro

Date July 13 1984

Time Start 1310 Time Finish 1340

Weather Clear, warm, light Breeze

Temperature Air 80 °F Water 75 °F

Type of Meter Digital Meter No. 1051

Spin before meas. ____ sec. after ____ sec. ok

Method (rod, cable, etc.) Rod

Horizontal angle coef. —

Suspension coef. —

Remarks —

Computations by J. Sczurko, F. Fitzgerald

Width 25.5 ft. Ave. Depth 1.1 ft. No. Sec. 28

Area 38.85 sf Velocity 0.95 fps Discharge 36.81 cfs

FIGURE 2

FIGURE 2 (CONTINUED)

Angle coefficient	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY: At point	VELOCITY: Mean in vertical	Adjusted for hor. angle or	Area	Discharge
LEW	0.0	0.5	0	.6				0.0		0.0	0.0
	1.0	1.0	0.7					0.0		0.7	0.0
	2.0	1.0	0.85					0.0		0.85	0.0
	3.0	1.0	1.1					.32		1.1	0.352
	4.0	1.0	1.3					0.58		1.3	0.754
	5.0	1.0	1.7					0.70		1.7	1.19
	6.0	1.0	2.0					0.85		2.0	1.7
	7.0	1.0	2.2					0.95		2.2	2.09
	8.0	1.0	2.1					0.98		2.1	2.058
	9.0	1.0	2.0					1.10		2.0	2.2
	10.0	1.0	1.7					1.15		1.7	1.955
	11.0	1.0	2.0					1.25		2.0	2.5
	12.0	1.0	1.85					1.30		1.85	2.405
	13.0	1.0	1.80					1.30		1.8	2.34
⊙	14.0	1.0	1.65					1.25		1.65	2.06
	15.0	1.0	1.60					1.28		1.60	2.05
	16.0	1.0	1.60					1.30		1.60	2.08
	17.0	1.0	1.50					1.25		1.5	1.875
	18.0	1.0	1.90					1.23		1.90	1.722
	19.0	1.0	1.30					1.20		1.30	1.560
	20.0	1.0	1.25					1.15		1.25	1.438
	21.0	1.0	1.20					1.10		1.20	1.320
	22.0	1.0	1.20					0.98		1.20	1.176
	23.0	1.0	1.10					0.98		1.1	1.078
	24.0	1.0	1.0					0.90		1.0	0.90
	25.0	0.75	1.0	.6				0.27		0.75	0.203
REW	25.5	0.25	0	-				0.0		0.0	0.0

Area = 36.85 m²

Discharge = 36.81 cfs

V. DATA MANAGEMENT

It is very important that the data produced by the water quality survey is properly recorded.

a. Field Notes

The field notes collected during the survey, as well as any general comments or impressions of the survey, should be summarized in a written memorandum within one week of the survey.

b. Data

All data sheets should be kept in one file which holds all data from the survey. This includes DO sheets, LES data sheets, and any data from inhouse testing (i.e., chlorophyll a, Microtox™). The coordinator should check all data sheets for results that appear improbable. LES data can be verified by contacting the Chief of Laboratory.

c. Data Management System

A computer based data management system, for riverine data is currently being developed. When this system is in place, it will be the responsibility of the survey coordinator to see that all field data is entered into the system and verified.

VI. SUGGESTED READINGS

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APPENDICES

Appendix A: Intensive Water Quality Survey Plan - 1986 Merrimack River Survey

Appendix B: Synoptic Water Quality Survey Plan - 1986 Mystic River Survey

Appendix C: Advanced Funding for In-State Surveys

Appendix D: Approval for Out-of-State Travel

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Appendix F: Winkler Method for Dissolved Oxygen

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APPENDIX A

INTENSIVE SURVEY OUTLINE

1986 MERRIMACK RIVER BASIN SURVEY

Coordinator: Nora E. Hanley

Dates: June 16-19 intensive surveys
August 11-14
T.B.D. mini surveys

I. Objectives:

1) To provide a data base of Merrimack River water and sediment quality (intensive surveys).

2) To evaluate significant New Hampshire discharges near the Mass. border and their effect on the river.

3) To evaluate water quality effects on Newburyport shellfish.

4) To investigate the Ward Hill, Haverhill landfill effects on the Merrimack.

II. Scope:

A. Intensive surveys - June and August

1. Bridge and shore crew

- Samples for chemical and nutrient parameters will be collected from 17 river locations 3 times daily on Tuesday and Wednesday.

- Bacteria grab samples will be taken twice daily on Tuesday and Wednesday during the 4:00 and 18:00 runs. They will be taken once on Thursday during the 11:00 run. Samples will be for fecal coliform for stations 1 through 16, and for total and fecal coliform for stations 17 and beyond.

- The runs will begin at the most upstream station in Tyngsboro at 4:00, 11:00 and 18:00.

- Chemical and nutrient samples will be composited daily from the 3 runs on Tuesday and Wednesday.

- Grab samples for heavy metals will be obtained on the 18:00 run on Tuesday.

- Water temperature and dissolved oxygen will be obtained on all 7 runs.

2. Boat crew - from Lowell to Lawrence

- Five additional sampling stations, downstream from the Lowell WWTP and upstream of the Lawrence Dam, will be sampled from a Boston Whaler, twice daily, on Tuesday and Wednesday beginning in Lowell at 11:00 and 16:00.

- Grab samples will be obtained at a one meter depth, midstream, for all water quality parameters but bacteria, which will be sampled near the surface.

- Chemical and nutrient samples will be taken on all four runs and composited daily.

- Fecal coliform bacteria will be sampled during each run.

- Grab samples for heavy metals will be taken once per week on Tuesday during the 16:00 run.

- Sediment samples will be obtained above the Lawrence Dam and analyzed for metals, nutrients and PCB's.

3. Boat crew - estuary

T.B.D.

B. Compliance Monitoring

- Seven or eight Mass. discharges will be sampled during intensive survey weeks.

- Two New Hampshire discharges will be sampled during intensive survey weeks by the state of New Hampshire and EPA.

Mass. Dischargers	N.H. Dischargers
Lowell WWTP	W.R. Grace
GLWWTP	Nashua WWTP
Western Electric	
Haverhill WWTP	
Merrimac WWTP	
Amesbury WWTP	
Newburyport WWTP	
Microfab	

C. Mini-surveys

1. Newburyport shellfish

- Will be sampled for bioaccumulation of toxics several times during the summer in cooperation with the DEQE Northeast Regional Office Shellfish Group.

- Corresponding sediments will also be sampled.

- Analyses will be for metals, and possibly organics/pesticides in accordance with EPA guidelines.

- Metals - cadmium, lead, mercury

- Organics - pesticides, PCB's, pentachlorophenol

2. Nashua, N.H. pollutant loading

- W.R. Grace and the Nashua WWTP will be sampled for various chemical, nutrient, bacteria and metal parameters.

- Sampling will be done jointly by the N.H. Water Supply and Pollution Control Commission (Jeff Andrews) and EPA.

- A river grab sample will be obtained above and below the Nashua WWTP.

3. Ward Hill landfill, Haverhill

- Water quality samples will be obtained by pram for various potential pollutants.

III. Personnel Requirements - Intensive Survey

1)	River sampling crew (bridge)	6	people (Friday, Tues.-Thurs.)
2)	Boat crew (Lowell-Lawrence)	2-4	people (Tuesday & Wednesday)
3)	Boat crew (estuary)	2-3	people (Tues.-Wed., if possible)
4)	Compliance	2	people (Monday-Wednesday)
5)	Coordinator	1	person (Friday-Thursday)
6)	Microtox	1	person (Wednesday, Thursday)
		14-17	people

IV. Vehicle Requirements

1)	Previous Friday	3	trucks
2)	Monday (Compliance)	1	truck
3)	Tuesday	4	trucks and 2 Boston Whalers
4)	Wednesday	4	trucks and 2 Boston Whalers
5)	Thursday	2	trucks
6)	Friday	0	

V. Samples - Intensive Survey - per week (not including Compliance)

Water Quality	Fecal or Total Chem./Nut.	Fecal or Total Bact.	Metals	VOA	Base Neutral Acid Extractables, Other Organics
Bridge crew	34	85	17	3	1
Boat crew (Lowell/Lawrence)	10	25	5	1	1 (3 sediment*)
Estuary crew	10	20	5		
	54/wk.	130/wk.	27/wk.	4/wk.	2/wk.

* Sediment & Shellfish

Lead
Cadmium (by furnace A.A.)
Mercury
PCB's
Pesticides
Pentachlorophenol

MERRIMACK RIVER SURVEY - 1986

LOCATION OF SAMPLING STATIONS

Station Number	Water Body	Location
MR01	Merrimack	Rt. 113 bridge, Tyngsboro
MR02	Merrimack	Lowell water intake, Rt. 113, Lowell
MR03	Merrimack	Inlet to Pawtucket Canal, Lowell
MR04	Merrimack	Ouelette Bridge, Lowell
MR05	Merrimack	Hunts Falls Bridge, Lowell
MR08*	Merrimack	Directly downstream of Duck Island
MR09*	Merrimack	Off Rt. 110 downstream of powerline, Dracut
MR11*	Merrimack	Below Rt. I-93 bridge, Methuen
MR12*	Merrimack	Upstream of water supply intake, Lawrence
MR13*	Merrimack	Off launch area, Riley Park, Lawrence
MR14	Merrimack	Rt. 28 bridge at canal inlet, Lawrence
MR15	Merrimack	Duck Bridge, Union St., Lawrence
MR16	Merrimack	Off the shore, Ayer St., Methuen
MR18	Merrimack	Rt. 125 bridge, Haverhill
MR19	Merrimack	Bates Bridge, Rt. 113, Haverhill-Groveland
MR20	Merrimack	Rocks Bridge, Haverhill-West Newbury
MR21	Merrimack	Essex-Merrimack Bridge, Amesbury
MR22	Merrimack	Rt. 1 and 1A bridge, Newburyport
CO02	Concord River	East Merrimack St., Lowell
BB01	Beaver Brook	Martin St. bridge, Lowell
SR0	Spicket River	Canal Street, Lawrence
PW0	Powwow River	Route 110 Bridge, Amesbury

Estuary stations - TBD

* These locations will be sampled by boat

APPENDIX B

SYNOPTIC SURVEY OUTLINE

1986 MYSTIC RIVER SURVEY

I. Introduction

The Mystic River Basin is located northwest of the city of Boston and is part of the Boston Harbor drainage system. The basin is depicted in the accompanying figure. The Mystic River is comprised of Hall's Brook and the Aberjona River in the upper portion of the basin; the Upper and Lower Mystic lakes in the middle portion; the Mystic River above the Amelia Earhart Dam, and the Mystic River estuary which flows into Boston Inner Harbor. The basin drains a total of 69 square miles and has been subjected to severe pollutant loadings, some of which continue to degrade the water quality and biological integrity of the Mystic River Basin.

II. History of MDWPC Monitoring of Mystic River Basin

The MDWPC has conducted several water quality monitoring programs of the Mystic River Basin. Surveys were conducted in the following years: 1967, 1973, 1978, 1979, 1980, 1981. The information from those surveys is published by MDWPC and is available upon request.

The results of the monitoring programs indicated that the Mystic River Basin was impacted by several factors including: urban runoff, combined sewer overflows, saltwater intrusion and leachate from toxic waste disposal sites. Two areas in the upper portion of the basin are Superfund sites; criminal proceedings are currently underway at one site. A project to de-salinate the Lower Mystic Lake is being planned by the Metropolitan District Commission (MDC). Most of the basin is serviced by the Massachusetts Water Resources Authority (MWRA) sewerage system with limited treatment provided at the MWRA's Deer Island primary treatment plant with discharge to Boston Harbor.

III. Objectives of 1986 Monitoring Program

The 1986 program has several objectives:

a. Update data base to reflect current water quality conditions.

b. Provide information for the 1988 305(b) report.

c. Evaluate the influence of combined sewer overflows (CSO's) and the effect of the de-salination project (if underway).

d. Provide baseline information concerning the presence of toxicants in the system.

IV. 1986 Monitoring Program Scope:

Sampling will be conducted on the following dates:

- May 20, 21
- July 29, 30
- August 26, 27

The monitoring locations are listed below:

STATION	NUMBER		DESCRIPTION	SAMPLING REGIME*
MY	2.0		Mystic River above Amelia Earhart Dam, Somerville	P,C,N,M,B,S,O
MY	2.8		Mystic River at Route 28, Somerville-Medford	P,C,N,M,B,S
MY	3.8		Mystic River at Route 16, Medford	P,C,N,M,B,S
MY	5.8		Mystic River at Route 38/16, Medford	P,C,N,M,B
MY	6.3		Mystic River at Boston Avenue, Medford	P,C,N,M,B
MY	6.5, 0.1	**	Alewife Brook at Mystic Valley Parkway, Arlington	P,C,N,M,B
MY	7.3		Mystic River at High Street, Medford-Arlington	P,C,N,M,B
MY	8.1		Outlet of Upper Mystic Lake, Medford-Arlington	P,C,N,M,B,O
MY	9.7		Aberjona River at USGS gage, Winchester	P,C,N,M,C,S
MY	10.7		Aberjona River at Washington Street, Winchester	P,C,N,M,B
MY	11.7		Aberjona River at Washington Street, Winchester	P,C,N,M,B,S,O
MY	13.1		Aberjona River at Washington Court, Woburn	P,C,N,M,B,S
MY	14.8E		Aberjona River at Mishawum Road, Woburn	P,C,N,M,B,S,O
MY	14.8W		Halls Brook at Mishawum Road, Woburn	P,C,N,M,B,S,O

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* P - physical: temp, pH, D.O.
C - chemical: BOD_5, TS, SS, Alk, Hard, Cl^-
N - nutrient: TKN, NH_3-N, NO_3-N, TP
M - metal: Al, Cr, Cu, Ni, Pb, Zn
B - bacteria: fecal coliform
S - sediment: % vol. solids, TKN, TP, Al, Cr, Cu, Ni, Pb, Zn
O - organics: VOA

** - 0.1 miles upstream on Alewife Brook from mile point 6.5 on Mystic River

Station MY2.0 My2.8, and MY3.8 will only be sampled during the July and August surveys. During the May 20 sampling, only physical parameters, bacteria parameters, and organics will be measured.

All monitoring will be conducted according to MDWPC established Standard Operating Procedures (SOP's) which are on file at the Technical Services Branch Office in Westborough. All analyses, with the exception of the physical parameters, will be conducted at the DEQE Lawrence Experiment Station.

River flow will be monitored by obtaining readings from the USGS gage located on the Aberjona River in Winchester. There are no major point source discharges to the Mystic River Basin. However, the Compliance Monitoring Section will review all minor discharges and determine if sampling is warranted.

V. Personnel and Vehicle Requirements:

The following are needed for each survey:

May 20 & 21: 1 vehicle; 2 personnel (1 from U.S. EPA)

July 29 & 30: 2 vehicles; 4 personnel
1 Boston Whaler

August 26 & 27: 2 vehicles; 4 personnel
1 Boston Whaler

VI. Other Information:

a. Samples will be delivered to LES in the P.M. (approx. 14:00) of each survey date.

b. Upper and Lower Mystic lakes might be sampled by Lakes Section.

APPENDIX C

ADVANCED FUNDING FOR IN-STATE SURVEYS

AF-5 approval is not required for in-state surveys; however, memoranda should be prepared well in advance to request funds for housing, meals and other expenses anticipated for all members of the survey team. These should be prepared by the survey coordinator, addressed to R.A. Isaac/A.N. Cooperman with copy to Administration Section (T. Vigneault) providing the following information:

1. Survey location

2. Time frame: departure and conclusion dates

3. Housing costs: room charges (incl. tax); number of rooms needed

4. Names of all personnel participating

5. Vehicles needed: registration numbers (use of private vehicles, with mileage allowances, is not allowed unless there are not enough state vehicles available to transport and conduct the survey).

6. Enumeration of any other additional costs, i.e., purchase of ice, etc.

If all information is submitted soon enough, advance checks will be disbursed to each individual for his/her costs for housing and meal allowances. The survey coordinator will receive any additional funds requested per his/her original request.

Because checks will be issued to each individual, it is very important not to make last minute changes in personnel.

Reconciliation of Funding

CD-18s (Travel Expense Vouchers) must be prepared by each individual upon return to Westborough after completion of survey and receipts for housing, etc. submitted. No receipts are needed for food, since food allowances are standard: $2.50 for breakfast, $4.00 for lunch and $7.00 for dinner. Departure from Westborough must be prior to 6:00 a.m. to qualify for breakfast and return after 6:00.p.m., for dinner. CD-18s can be obtained from the Administration office.

The reverse side of CD-18 should be completed chronologically with following information: time of departure from Westborough; mode of transportation (reg. no. if state vehicle); destination; name of motel/hotel; survey location; date of completion; arrival time in Westborough; and any other pertinent information. If a room was shared, each individual must submit his/her own receipt.

APPENDIX D

APPROVAL FOR OUT-OF-STATE TRAVEL

AF-5 Blanket Approval

For surveys involving incursion into neighboring states--either personnel or vehicles--requires out-of-state approval. In order to comply with this, survey coordinator should give the following information to TSB Administration Section so AF-5 can be prepared well in advance of proposed survey.

AF-5 Tracking

1. In-house approval

2. In-house preparation and submission to DWPC

3. Approval by DWPC

4. Approval by DEQE

5. Approval by the Secretary of Environmental Affairs office. The Secretary requires that AF-5s reach his office no later than ten working days before anticipated travel.

APPENDIX E

TECHNICAL SERVICES BRANCH 1987 MONITORING PROGRAM

Location:

Coordinator:

Date(s) Sampled:

Stations:

Delivered to LES:

Person Delivering:

Analysis: Number:

Chem/Phys ( ):

Nutrient ( ):

Bacteria ( ):

Metals ( ):

Organics ( ):

Other ( ):

Return to TSB monitoring coordinator/LES contact Wednesday 12:00 10 days prior to survey.

APPENDIX F

WINKLER METHOD FOR DISSOLVED OXYGEN

I. Winkler Method

A. Reagents (Provided by Lawrence Experiment Station)

1. Manganous sulfate solution (#I)

   a. 364 $MnSO_4.H_2O$ or
      400 $MnSO_4.2H_2O$ or
      480 $MnSO_4.4H_2O$
      dissolved in distilled water to 1 liter

2. Alkaline-iodide-azide Reagent (#II)

   a. 500g NaOH or
      700g KOH
      dissolved in distilled water with

   b. 135g NaI
      or 150g KI
      dissolved in distilled water, diluted

   c. 10g NaN_3 in 40 ml distilled water

   d. Add c to solution a + b with stirring

3. Sulfuric acid, concentrated

4. Starch indicator

   a. Heat distilled water

   b. Add 5 g/L starch

5. Sodium thiosulfate solution 0.0375N

B. Procedure

1. With tip of dropper below surface of full 30 ml sample add:

   a. 2 ml manganous sulfate solution (#I)

   b. 2 ml alkaline-iodide-azide reagent (#II)

2. Stopper, rinse, shake

3. Allow precipitate to settle and shake again

4. Allow precipitate to settle

5. With tip of pipette above surface add 2 ml concentrated H_2SO_4

6. Stopper, rinse, shake to dissolve precipitate

7. Transfer to flask & tritrate with 0.0375N thiosulfate solution to a pale straw color

8. Add 2 ml starch indicator solution and titrate to first disappearance of blue color

C. Calculations

1. 1 ml of 0.0375 N thiosulfate = 1 mg/L dissolved oxygen

D. Theory

1. Oxidation of manganous sulfate by O_2 in water

$$MnSO_4 + 2\ KOH = Mn(OH)_2 + K_2SO_4$$

$$2\ Mn(OH)_2 + O_2 = 2\ MNO(OH)_2$$

2. Manganous hydroxide is white precipitate which changes to brown when oxidized. Reaction with O_2 occurs on surface of floc, so mixing is important.

3. When manganic hydroxide is acidified, manganic sulfate is formed.

$$MN\ O(OH)_2 + 2H_2SO_4 = Mn(SO_4)_2 + K_2\ SO_4 + 3H_2O$$

4. In the presence of iodide the manganic salt acts as an oxidizing agent, releasing free iodide

$$Mn(SO_4) + 2KI = MnSO_4 + K_2SO_4 + I_2$$

5. The iodine which is stoichiometrically equivalent to the D.O. of the sample is titrated with thiosulfate

$$I_2 + 2Na_2S_2O_3 = Na_2S_4O_6 + 2NaI$$

$$2Na_2S_2O_3 = I_2 = Mn(SO_4)_2 = 2MnO(OH)_2 = O_2$$

APPENDIX G

MASSACHUSETTS DIVISION OF WATER POLLUTION CONTROL

WATER POLLUTION SECTION

FIELD LABORATORY SHEET

RIVER SURVEY..... DATE .....

STATION	RUN NO.	TIME	TEMP.	BURET READING	D.O.
				FIN.....	
				INT.....	.....
				FIN.....	
				INT.....	.....
				FIN.....	
				INT.....	.....
				FIN.....	
				INT.....	.....
				FIN.....	
				INT.....	.....
				FIN.....	
				INT.....	.....
				FIN.....	
				INT.....	.....
				FIN.....	
				INT.....	.....
				FIN.....	
				INT.....	.....
				FIN.....	
				INT.....	.....

APPENDIX H

PROCEDURE FOR DISSOLVED METALS SAMPLES

Approximately 400 ml of filtrate is needed for metals analysis. The total metal sample is filtered through an 0.45 um membrane filter using a vacuum pump. The filtering apparatus must be cleaned before each sample is filtered. The filter holder and filter flask must be washed with a 30% HNO_3 solution, and then rinsed three times with distilled, deionized water. A second flask should be used between the pump and the filter flask to act as a moisture trap. The pump will be damaged if any moisture is allowed to back up into it.

Use forceps to place the filter onto the holder. Only the outside edge of the filter should be touched. To prepare the flask, a small amount of sample (approximately 25 ml) should be passed through the filter. Rinse the flask with the filtrate and discard.

As the sample passes through the filter, solids will accumulate on the filter and the filtration rate will decrease. Replace the filter when the filtration rate becomes very slow.

The filtered sample is processed in the same manner as a metals sample. The filtrate is transfered to an acid-washed sample bottle and fixed with nitric acid. Dissolved metal samples are acidified <u>after filtration</u>. Samples should be filtered immediately after collection.

APPENDIX I

MICROTOX™ SAMPLING PROCEDURES

Please use the following procedure when taking samples for Microtox™ toxicity analyses.

1. Use clean - washed and rinsed twice with distilled water - 16 ounce glass jars with teflon-lined caps. Jars should be filled completely to eliminate any headspace.

2. Samples can either be grab or composites but must "match" samples sent for chemical analysis.

3. Both pH and Total Residual Chlorine (TRC) readings should be taken in the field and noted on the sample tag. If the sample is a composite then the TRC measurements should be taken on the composite.

4. The following parameters should be analyzed to the detection limit (mg/l) specified:

hardness	0.5	the following total metals:	
alkalinity	2.0	Ag, Cd, Cu, Pb	0.005
TRC	0.02	Cr, Ni	0.1
ammonia	0.1	Al, Fe, Zn	0.2
TKN	0.03	Specific Conductance	--
TOC	0.5	Total & Suspended Solids	10 & 2

5. The samples should be stored on ice for transport back to the lab.

Also, the following information should be recorded on the tags:

SOURCE/TOWN:

SAMPLING DATES: both dates if 24-hour composite

SAMPLE TYPE: grab or composite i.e. 24-hour composite, 12-hour composite/ 6-hour intervals, etc.

SAMPLING LOCATION: exact location i.e. final effluent at end of discharge canal, etc.

pH:

TRC: